

NASA

QUALITY FUNCTION DEPLOYMENT FOR LARGE SPACE SYSTEMS

"Guidelines for Implementation of Quality Function Deployment (QFD) in Large Space Systems"

Final Report

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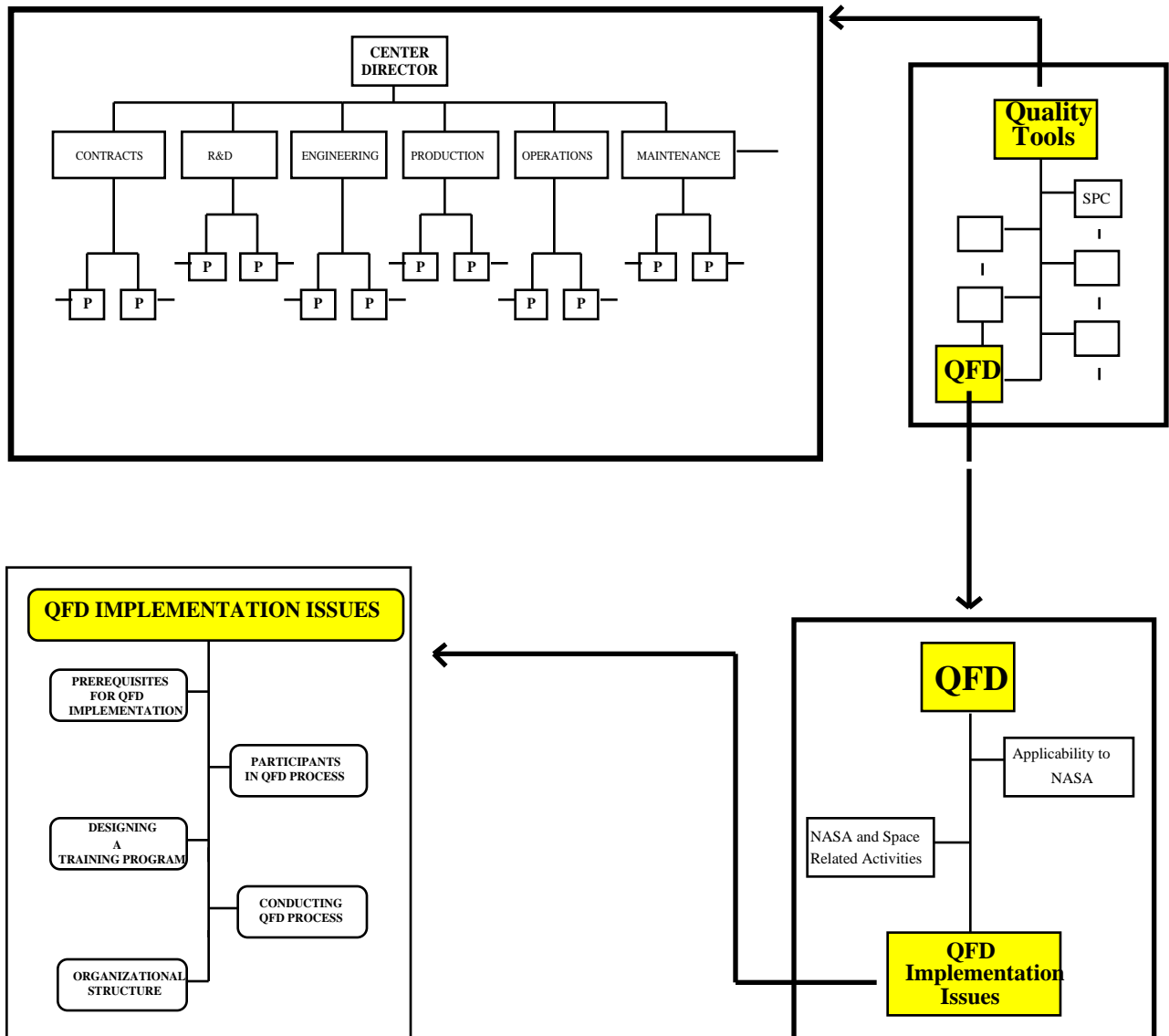
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Table of Contents

Using This Guide	1.0
Introduction	2.0
Current Issues in Organizations	
QFD Definition	
Considerations of QFD Definition	
QFD Approach	
Applicability to NASA	3.0
NASA and Space Related Examples	4.0
QFD Implementation Issues	5.0
Prerequisites for QFD Implementation	5.1
Participants in QFD Process	5.2
Designing a Training Program	5.3
Conducting QFD Process	5.4
Organizational Structure	5.5
Mechanisms of QFD	6.0
Bibliography	



Like Quality Function Deployment, this book is a tool!

This manual is intended for use by managers, both technical and personnel, decision makers, and "doers" in situations where products or processes are being developed, redesigned, or where improvements are being sought. It is intended to provide its users with questions and considerations concerning the use of QFD as a tool in their organizations. It is both broad in scope and yet detailed and specific on those basic "hard spots" for most managers and decision makers.

Chapters 2 through 4 of the manual provide NASA users with pertinent background regarding the use of QFD within NASA. Chapter 2 presents a brief introduction that addresses current issues in organizations relevant to the use of QFD, an expanded definition of QFD, and the basic QFD approach. Chapter 3 discusses the applicability of QFD to NASA projects and program developments. Chapter 4 presents several NASA specific examples of QFD use.

Chapter 5, QFD Implementation Issues, includes implementation considerations, discussion of the benefits and consequences of attendance to each consideration, narrative summaries, and a set of questions to be used as an implementation checklist. Bad consequences are usually only present when proper consideration was not given and best practices were not observed. Key considerations are identified for each implementation issue. If a manager properly addresses each consideration and employs best practices, then the overall risk surrounding the use of QFD on the project will be minimum.

Each section contains telltale alerts or warning signs which are indicative of an improper approach. These are called "indicators" and usually contribute directly to unacceptable project, product, or process consequences. The specific actions to be taken to realize the optimum benefits of best practices are termed "implementation hints", and if applied, reduce program risk. It is important to note that it is never too late to jump onto the best practice approach although the switch usually becomes more costly as the program progresses.

Chapter 5 is grouped by function and each topic is described by four elements:

1. The CONSIDERATIONS, accompanied by a brief definition of the topic.
2. A COMPARISON discussion, which compares the consequences of improper approaches to the benefits of best practices for each consideration, and including both the INDICATORS of improper approaches and the IMPLEMENTATION HINTS for best practices.
3. A SUMMARY which briefly discusses improper approaches and best practices.
4. A QUESTIONS portion to aid the manager and decision maker in taking advantage of the best practices.

Chapter 6, Mechanisms of QFD, presents a primer on QFD that is intended to familiarize those who may not have formal training in QFD methods, by means of an overview. Although it is not a complete training program, it should provide the reader with adequate background to understand and apply the guidelines presented from a management perspective.

This guide illustrates that many of the approaches used in past attempts at QFD are not best practices and have led to unproductive, time consuming, costly, and frustrating experiences. The manual should first be reviewed thoroughly to understand the interpretation of the current QFD implementation process with respect to pitfalls. The format of the manual has been designed to make this review easy and fast, by providing instant focus on critical issues. The first-time reader should scan the CONSIDERATIONS on the first page of each section. Each subsection becomes increasingly explanatory and one need read only as far as he or she finds necessary.

If currently trying to use QFD as part of a project, the user should use this book as a guide to review the implementation process and determine which CONSIDERATIONS may have been overlooked. Plans to rectify any deficiencies will depend upon what stage the project is in, as well as the availability of resources that may be required. In many instances, it will be discovered that corrections can be made with little or no additional resources. In others, however, one must be prepared to stop wasting valuable resources on ill-fated implementations by stopping the process and evaluating what went wrong and what to do now.

This book is intended as a guideline and outlines a model process. It was conceived by people who have used QFD as a tool to identify critical product and process attributes and functions in various governmental and industrial settings. This book itself was developed using QFD techniques as a framework for content and format definition. It is essential to recognize that no individual or organization uses all the best practices described. This guide brings together a compendium of the key considerations and best practices distilled from a broad experience base.

THE REST IS UP TO YOU !

ORGANIZATIONAL STRUCTURES

Most companies are still organized in traditional hierarchical organizational structures. These organizations usually have extremely strong vertical lines of communication and control which make it difficult to implement a new technology or program. (The ultimate desired organizational structure would be one having strong horizontal lines as well as vertical lines). Consequently, in many organizations, the **PRODUCT DEVELOPMENT PROCESS** is not clear to all members because of the "formalized" procedures for **PRODUCT DEVELOPMENT** implemented in the hierarchy. In other words, how **CUSTOMER REQUIREMENTS** are converted into a product is a mystery.

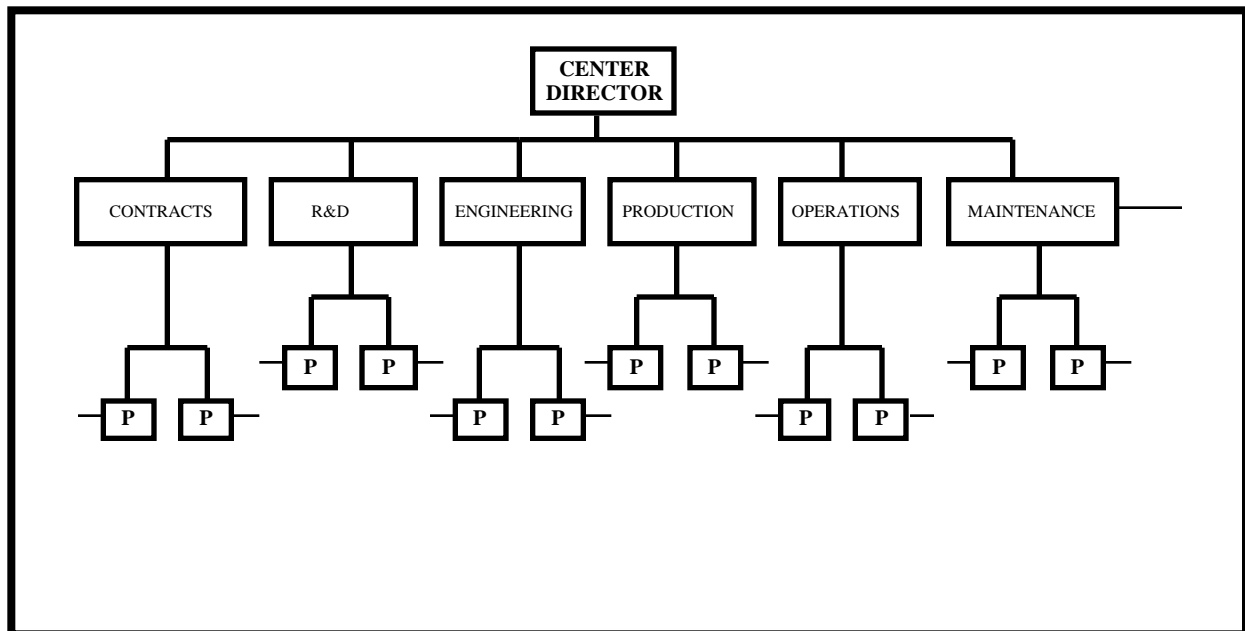


Exhibit 1. Traditional Organization Structure.

ORGANIZATIONAL COMMUNICATION

In most organizations, **INFORMATION** is transferred through the various functions. During **PRODUCT DEVELOPMENT**, the process of information transfer required to incorporate **CUSTOMER REQUIREMENTS** into a delivered **PRODUCT** is complex. Communication among the functional groups with each having its own "language" and "interpretation" of language gives rise to the complexity.

NEED FOR A TOOL?

In large organizations developing complex products, these organizational and communications issues are magnified. Regardless of the efforts of the organization, the risk of failure to deliver the **PRODUCT** which is in line with **CUSTOMER REQUIREMENTS** is high. **QUALITY FUNCTION DEPLOYMENT** is a tool which provides a mechanism for "translation and documentation" of the product development process, and if properly implemented, significantly reduces that risk.

Defining Quality Function Deployment (QFD) has a risk of narrowing its meaning, application areas, and potential benefits. However, one definition given by American Supplier Institute, Inc. captures the essential meaning:

QFD DEFINITION

A System For Translating Consumer/Customer Requirements Into Appropriate Company Requirements At Each Stage From Research And Product Development To Engineering And Manufacturing To Marketing/Sales And Distribution.

CONSIDERATIONS OF QFD DEFINITION

One should be careful about interpreting the above QFD definition:

- QFD is ***NOT*** only for ***PRODUCTS***, but it is also for ***PROCESSES*** and ***SERVICES***.
- QFD is ***NOT*** only a ***QUALITY TOOL***, but it is also a ***PLANNING TOOL*** for "enhancing" existing ***PRODUCTS***, ***PROCESSES*** and ***SERVICES*** as well as "introducing" new ***PRODUCTS***, ***PROCESSES*** and ***SERVICES***.
- QFD is ***NOT*** to be used only by ***QUALITY MANAGEMENT DEPARTMENTS***, but it should be used at ***ALL LEVELS*** of an organization as a planning tool.
- The ***END USER*** is not the only customer. The ***ORGANIZATION*** itself should also be treated as a customer, to incorporate the organization's goals.

QFD APPROACH

In discussing the basics of the QFD approach, the term "***PRODUCT***" will be used for simplicity; ***PRODUCT*** will correspond to any of the following:

- Assemblies of components.
- Components.
- Combination of "ingredients" or "materials".
- Non-physical products such as services.
- Combination of services.
- Processes.

One should use any of the above as it applies to the type of product under consideration.

QFD integrates the "voice of the customer" with all the required functions for a product. Therefore, QFD approach begins with capturing the needs, demands and requirements of the customer.

OFD is applicable to all levels of requirements which describe the product. These requirements are manifested, and addressed by QFD techniques, in four stages of the product development cycle.

DESIGN REQUIREMENTS

Usually, customer requirements are expressed in "vague" qualitative terms such as "easy to use" or "comfortable". These requirements must be translated into a form that the organization can interpret and analyze. During the design requirements stage, those product characteristics that are of interest to the customer are identified.

PART REQUIREMENTS

The design requirements definition stage looks at the product from a "systems perspective". The next step is to translate design requirements into "specific parts/components". During part requirements stage, characteristics of those parts that will effect the design requirements are identified. (This stage applies to those products that are assemblies of components, combination of materials, and combination of services).

MANUFACTURING REQUIREMENTS

As design and parts requirements are established, the required operations to achieve these requirements must be determined. This phase is affected by the resource (equipment, labor, capital) constraints placed on the organization. Considering all the constraints, the organization must identify those operations that are critical in achieving the design and parts requirements.

PRODUCTION REQUIREMENTS

The last stage, production requirements, determines the "procedures" and "practices" that will result in production of the final **PRODUCT BASED ON THE CUSTOMER NEEDS**.

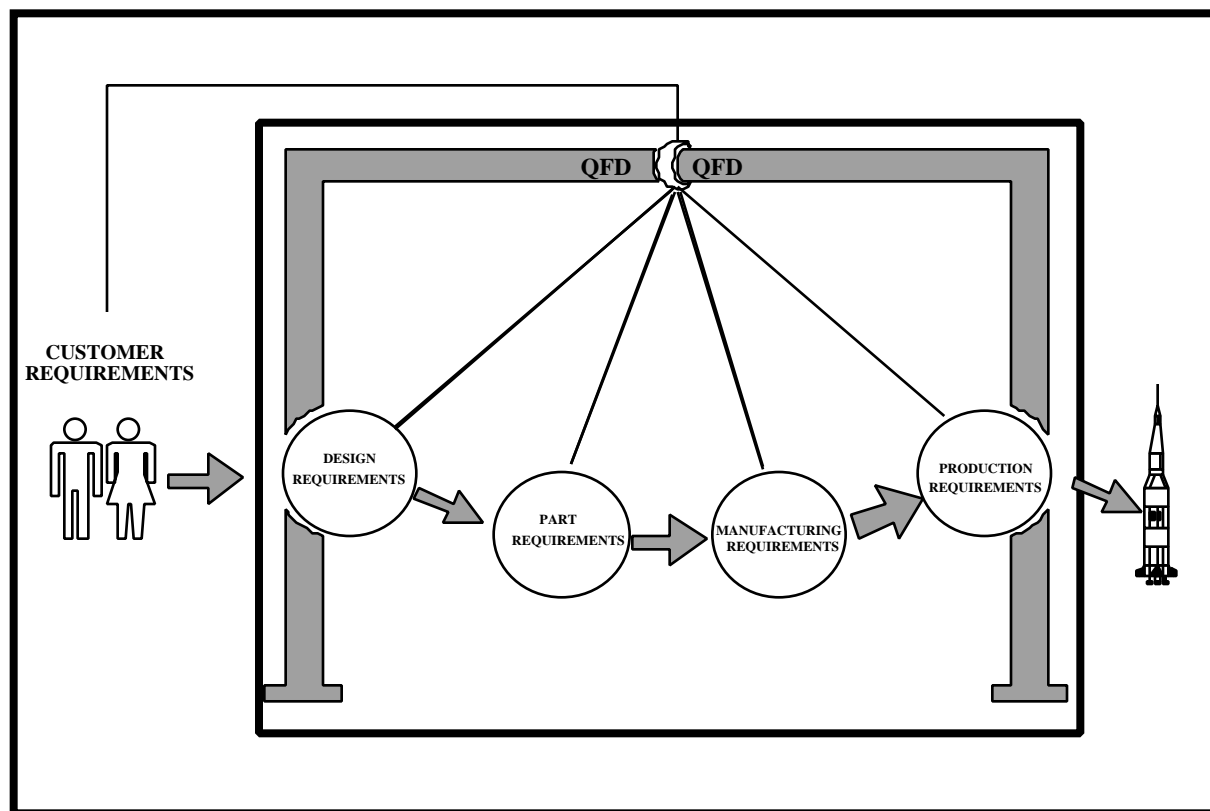


Exhibit 2. QFD Approach.

Applicability of any tool to any process is a reasonable concern for managers and decision makers. Questions emerge surrounding cost of use, value added, effect on process or product performance, total quality, schedule, qualifications for use, and ease of use. QFD as a tool to identify the important attributes or functions of a product or process in the context of the user as well as the producer is a basic tool for any project. QFD becomes a way of thinking about developing products and doing processes. In this context, QFD is arguably applicable to some degree of implementation at every level of project development.

For NASA projects where the organization is established around the project itself, QFD is most applicable since the problem focus is upon the project itself and the project structure provides the taxonomy for discussion. The difficulty here is that often the project requirements are defined outside the project organization, and in some cases by many players, making it difficult to identify the real "voice of the customer". QFD is still very useful in this context as a tool drive out the real requirements, prioritize those requirements, and serve as a negotiating tool with the outside organizational customers.

Furthermore, NASA and its customers are concerned about its programs and systems meeting their basic functional requirements, the ability of these programs and systems to perform their functions over the life cycle, the maintainability of these systems, and the safety aspects of these systems. QFD addresses all these aspects of product life cycle and the processes necessary to create, care, and operate these products.

Beyond the initial planning phase for a project, level or phase of project development is a matter for consideration for QFD applicability. Although QFD may be applicable to every phase, the level of implementation becomes the key concern. More important is the level of organizational understanding about the problem being addressed. It may not be necessary to construct multiple levels of "houses of quality" for every problem, but it may be useful to revisit the basic functionality of project elements, especially to discover that traditional treatments have been superseded or are no longer necessary. The manager that makes the decision to use or not to use QFD for a portion of the project must be careful not to eliminate the need for QFD processes where basic functionality needs to be assessed. One cannot specify the use of QFD for every element either or nothing will get done in an efficient manner.

The type of project must be considered when making a decision regarding the use of QFD. Industry has effectively used QFD for every level of product development, from an entire automobile concept to the side view mirror for that vehicle. That obviously does not mean that one need be an automobile design engineer to use QFD or that QFD should be employed for design of every component of hardware development. Its traditional use in product development does indicate that QFD may be easier to use where some physical component provides the framework for discussion in its design definition. Where services or processes are definable at some level to allow discussion, QFD may be employed as well. The following section describes some examples of using QFD in addressing process and service issues.

INITIAL STRATEGIC PLANNING STAGES

In examining the applicability of QFD, it must be remembered that it may be applied to process and service improvement as well as product development. Since it has been shown to be an effective planning tool, QFD should certainly be applied to strategic and high level program definition where decisions are made about what will be developed, what the system capabilities should be, who the intended users are, and introduction schedule. This high level process is often referred to System Requirements Definition and establishes the highest level of functionality for the system. This is process rich in consideration of the "customer", filled with long term and high cost decisions, and often concerned with technological risk, yet many times system baseline concepts are derived without the benefit of a tool like QFD to provide the coordinating framework and analytical rigor necessary to choose the best design parameters. QFD is applicable to and should be used in the initial planning phases for all projects.

DESIGN AND PREPRODUCTION STAGES

The ultimate goal in product development is to achieve *HIGH QUALITY, RELIABLE and COST EFFECTIVE* products while being able to *RESPOND QUICKLY* to market demands. Even if QFD tool might seem somewhat cumbersome and time consuming, it provides a "short cut" to this goal. QFD identifies the related customer requirements, design requirements, manufacturing requirements by incorporating the quality factors and characteristics associated with each requirement. QFD initiates a "quality plan" and "quality design" at the early stages (planning) of the process and continues until product is deployed. OFD plays a critical role in determining the quality related relationships between the final product and its each subsystem which will ultimately effect the *RELIABILITY* of the total system.¹ In addition, there are number of steps during the product development that overlaps. The functional groups involved in the process need to "communicate effectively with each other", and QFD will act as a bridge among the participants. The benefits can be easily seen in the decisions to be made related to new material, new technology and new production lines and equipment.

¹Akao, Quality Function Deployment, 1990.

PROCESS DESIGN STAGES

The process requirements need to be identified and designed to ensure a process that is *CONTROLLABLE and MANAGEABLE* to produce high quality products. Again, QFD, similar to design stage, can provide a "short cut" to achieve this goal by incorporating the product quality standards, inspection parts and standards when determining process requirements. The outcome of QFD then becomes part of the "process control items" (check points) to plan for critical components and parts.² During the process design, QFD benefits can be easily seen in:

- Areas that require close attention as a result of changes in material, and specifications due to design constraints.
- Areas that require close attention for quality improvements
- Safety factors
- Effects on total system when design tolerances are not met.
- Comparison of processes and process capabilities using existing equipment.
- Identification of engineering bottlenecks, production problems and areas for improvement.
- Comparison of costs for different process methods.

RELIABILITY AND MAINTAINABILITY

In deploying quality in product function, reliability must be deployed as a part of this process to assure lifetime utility of the product. Reliability is *NOT simply* producing the product according to the plan and following the instructions. Reliability and maintainability of a product requires special attention during the early stages of the product development cycle specifically in the planning and design stages. To maintain reliability, it has to be incorporated throughout the entire production stage. When considering reliability, one need to determine the quality factors and characteristics which will effect the reliability and maintainability of the system over its life-cycle. OFD can be effectively used as a framework to identify the reliability and maintainability "whats" and "hows" and then set tolerances for engineers. The benefits of QFD can be recognized in:

- Identifying the factors that can cause problems (e.g. environment, conditions).
- Comparison of the effects by changing conditions and environment that affect product life.
- Identifying the components that need improvements.

²Akao, Quality Function Deployment.

There are number of examples of QFD application as a planning or quality tool found in various programs throughout NASA. In some cases, some forms of QFD concepts have been applied. Those examples range from product related to non-product related activities.

***REQUIREMENTS AND DEVELOPMENT
CONSIDERATIONS FOR THE
SPACE TRANSPORTATION MAIN ENGINE (STME)***

USAF and NASA have successfully implemented QFD to develop customer/user requirements for the Advanced Launch System (ALS). Even though the requirements had been set under the Department of Defense process, to accomplish the program goal of "*defining a launch system which was operational from the point of view of the operators themselves*", QFD was adopted. The experiment was designed specifically to define the quality characteristics required of the STME which would result in ***LOW COST and HIGHLY RELIABLE*** STME. The QFD project was conducted by ten member team over a five month period. The project team members represent design, development and manufacturing functional groups. The project involved eight major organizations as the customers for identification of the requirements. Design requirements and relative importance of each requirement for the STME were identified. The following is the resultant customer requirements:

World Class Engine

Robust - (physical, program, operational)

Reliable - (no catastrophic failures, minimum engine shut down)
(control benign failure)

Cost Effective - (cost effective performance, low operation cost)
(low production cost)

Operation Utility - (mission flexible, adaptable, launch dependable)

Socially Dependable - (safe, environmentally acceptable)
(politically acceptable)

***ADVANCED LAUNCH SYSTEM (ALS)
CRYOGENIC TANK***

USAF and The Aerospace Corp. have initiated an activity targeted at the ALS cryogenic tanks to improve ***OPERABILITY and RELIABILITY and REDUCE COST***. The QFD project team members are representatives of manufacturing, vehicle design, structures and operations functional groups (government and contractors). The experiment resulted in establishing the cryogenic tank customer requirements and how to meet the requirements, and ranking of the technical solutions. The customer requirements are related to performance, structural design, operations, system cost, safety, and manufacturing.

TACTICAL AIRCRAFT DEVELOPMENT

McDonnell Douglas Aerospace-East developed a process which utilizes QFD to help understand the potential world futures and their implications. This application demonstrates how National goals can be linked with successive levels of military policy in order to illustrate the impact of these policies on future aircraft force structure requirements. These top level requirements are further deployed to provide a first-order understanding of required aircraft capabilities and the technologies to achieve them.

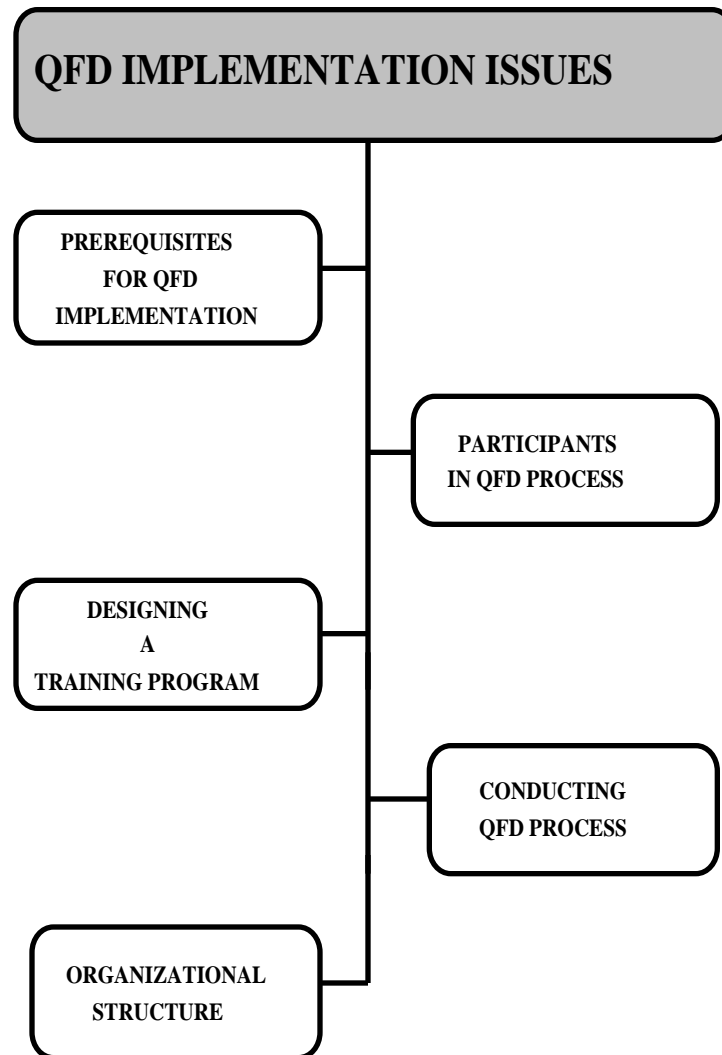
STRATEGIC PLANNING SUPPORT EFFORT FOR ETO TRANSPORTATION and PROPULSION SYSTEMS

The space Propulsion Synergy Group (SPSG), which is composed of representatives from NASA, DOD, DOE, and Universities and supported by the aerospace industry, was formed to address three key issues:

- "The lack of a recognized national space propulsion strategy is detrimental to U.S. space program and international posture".
- "There exist major gaps between technology developers and users, and means of correcting this is essential."
- "Technology users (i.e., propulsion system developers, producers, and operators) should provide their real requirements, and share in technology program planning and funding."

The SPSG adopted QFD tools to approach these issues and achieved the following objectives:

- Provide long range strategic planning support.
- Improve space propulsion technology communications.
- Make propulsion system evaluations and recommendations.



OVERVIEW

As with any tool, there are prerequisites for effective use of QFD. Agreement upon a clearly articulated problem to be addressed by QFD is essential to its effective use. This is another way of saying that it is necessary to know what to be done before selecting a method or tool for doing it. Once the problem is clearly stated, commitment by management and workers is a must in accomplishing the task effectively. While the focus and commitment are necessary, they also are not sufficient to guarantee a successful QFD implementation. Knowledge of and experience in the use of the tools and methods being equally important. A clear understanding of the expectations when using a tool completes the prerequisite considerations for use.



- 1. U**nderstanding and articulation of the problem.
- 2. R**eceptiveness of users to QFD methodologies.
- 3. M**anagement support and participation.
- 4. K**nowledge of and experience in applying QFD techniques.
- 5. U**nderstanding of potential benefits and costs of use.

PREREQUISITES FOR IMPLEMENTATION 5.1

{1. Understanding and articulation of the problem.}

IF CONSIDERED

BENEFITS TO BE ACHIEVED

- Clear focus on issues.
- Rapid definition of objectives.
- Identification of appropriate participants.

IMPLEMENTATION HINTS

- Use group process to define a formal problem statement.
- Make formal problem statement available to potential participants and their managers.
- Structural process to identify customers and their requirements.

IF NOT CONSIDERED

INDICATORS OF POOR PRACTICE

- Too much time spent defining issues/objectives.
- Complaints of lack of focus by participants.
- Lack of expertise among participants.

BAD CONSEQUENCES

- Inappropriate people assigned to QFD team.
- Failure to focus on critical issues.
- Inefficient use of participant's time.

PREREQUISITES FOR IMPLEMENTATION 5.1

{2. Receptiveness of users to QFD methodologies.**}**

IF CONSIDERED

BENEFITS TO BE ACHIEVED

- Enthusiastic team participants.
- Enhanced productivity of teams.

IMPLEMENTATION HINTS

- Recruit participants who have been enthusiastic contributors during previous QFD activities.
- Interview prospective participants regarding their willingness to participate.

IF NOT CONSIDERED

INDICATORS OF POOR PRACTICE

- Negative and/or counterproductive team members.
- Complaints about methodology and process.

BAD CONSEQUENCES

- Lack of progress toward objectives.
- Resignation of normally productive team members.

PREREQUISITES FOR IMPLEMENTATION 5.1

{3. Management support and participation.}

IF CONSIDERED

BENEFITS TO BE ACHIEVED

- Positive organizational attitude toward QFD and other continuous improvement initiatives.
- Eagerness to apply QFD.
- Unsolicited identification of their potential applications.

IMPLEMENTATION HINTS

- Managers must "walk the talk" concerning QFD and other continuous improvement methodologies.
- Solicit support from other managers regarding the use of QFD.
- Educate managers regarding the capabilities and use of QFD.

IF NOT CONSIDERED

INDICATORS OF POOR PRACTICE

- Lack of resources to support QFD effort.
- Lack of participation by managers.

BAD CONSEQUENCES

- QFD becomes "just another management buzzword".
- Resources wasted on futile QFD efforts.

PREREQUISITES FOR IMPLEMENTATION 5.1

{4. Knowledge of and experience in applying QFD techniques. }

IF CONSIDERED

BENEFITS TO BE ACHIEVED

- QFD begins to function quickly.
- New ideas are born from a synergy of diverse experience.

IMPLEMENTATION HINTS

- Ensure potential QFD team members receive formal training.
- Choose participants who have experience using QFD.

IF NOT CONSIDERED

INDICATORS OF POOR PRACTICE

- Too much meeting time is spent learning about the QFD process.
- Team members cannot construct the basic "house of quality".
- QFD team is ineffective in performing analyses.

BAD CONSEQUENCES

- QFD team meetings are a waste of time.
- QFD team members become frustrated with the process and cease participation.

PREREQUISITES FOR IMPLEMENTATION 5.1

{5. Understanding of potential benefits and cost of use. }

IF CONSIDERED

BENEFITS TO BE ACHIEVED

- QFD process is begun with reasonable expectations.
- Management is not promised more than can be delivered.
- Resource requirements known at start.

IMPLEMENTATION HINTS

- Include potential benefit and cost of use elements of QFD training.
- Check with other users of QFD regarding realization of expectations.
- Perform a cost/benefits analysis prior to proceeding on a QFD project.

IF NOT CONSIDERED

INDICATORS OF POOR PRACTICE

- QFD team members complain about pressure to produce the impossible.
- Additional funds are required for ongoing QFD efforts.

BAD CONSEQUENCES

- QFD process is not used to its full potential.
- Managers and users hold unreasonable expectations about QFD use.
- Budgets do not reflect costs of needed resources.
- Investment in QFD projects exceeds the benefits realized.

DISCUSSION AND SUMMARY

In order to reach closure, any endeavor must have an identifiable and observable objective. The objective of an organization's product or service development process is to provide a product for a customer (or set of customers). The objective of a QFD program is to ensure that the products demonstrate the attributes and qualities desired by the customer. Consequently, the success of the QFD process hinges on the organization's ability to identify the customers (internal as well as end user) and become attuned to what they expect from the product. In other words, the organization must be able to understand and articulate the problem at hand, in terms of what the customer desires.

In public sector organizations dealing with large-scale development programs, identification of the customer may not be as straightforward as it appears. Project sponsors are not always the end users, and there are often political implications of product development decisions. There may also be organizational goals and objectives which can conflict with, or at least draw some resources from, efforts to satisfy end user requirements. Within the organization, the various functional elements become customers of other elements, depending on the stage of the development cycle.

What sets the QFD process in motion is a strategic decision (made at an organizational level above that at which QFD is to be applied) to target some product, service or process for improvement, or to initiate development of a new product or service. This decision may be the result of a QFD application at the higher level. What is required for the QFD process to be successfully initiated is a formal problem statement, derived directly from that strategic decision, that can be adopted as the goal of the QFD process. In the absence of a clear problem statement, the process is likely to lack direction and not produce the desired result.

Each problem statement has its own unique set of circumstances, and each organizational element has unique relationships with its customers and suppliers. It is, therefore, impossible to specify a "procedure" for hearing the "voice of the customer." Some suggestions, however, may establish a framework. Initially, a QFD brainstorming session should be conducted to identify the customers of each stage and intermediate product of the development/modification project. Once the customers are identified, information which describes the kinds of requirements they have should be solicited, and a dialogue should be initiated between the customer and the organizational functional element(s) responsible for designing to those requirements. For example: if a customer is concerned with the reliability of a spacecraft system, conversations should be conducted between that customer and a representative of a reliability and maintainability engineering function. Once all of the customer requirements have been addressed in this manner, QFD working group meetings should be conducted to synthesize as many of the requirements as practicable into the product design/redesign.

DISCUSSION AND SUMMARY (Continued)

The ability to accomplish these tasks, and to successfully implement the customer requirements into the final product is largely dependent on the people who populate the QFD team. The implementation hints provided in items 2 through 4 of this section and Section 5.2, to follow, are intended to help establish a productive and effective team, with the full and continuous support of management. "Commitment of management" may be an overworked phrase in this and many other discussions of continuous improvement and total quality initiatives, but the simple fact is that without it, any such program is doomed to failure.

The final issue discussed in this section refers to the costs and benefits of a QFD program. This guide goes on to recommend a formal training program for potential QFD participants. The QFD process will also require a certain amount of time from some of the organization's most valuable individuals. Other resources will be required to support the logistics of the QFD program. All of these are measurable and controllable elements of cost. It is important for the organization to be aware of the cost associated with the overhead of the QFD program and the direct costs associated with performance of a QFD project. They must be weighed against the potential benefits of any given project, and the program as a whole. Note that a good way to identify potential benefits is via a QFD-type brainstorming session.

QUESTIONS TO BE ASKED

1. Does a formal problem statement exist to be addressed by QFD process?
2. Is the problem clearly articulated in the language of the organization?
3. Has the problem statement been made available to potential participants and their managers?
4. Has a cost/benefits analysis been completed regarding use of QFD on this effort?
5. Are the resource requirements known and are they acceptable?
6. Has management been appraised of reasonable expectations for this effort?
7. Have potential participants been interviewed regarding their willingness to participate?
8. Have managers agreed to commit appropriate personnel to the effort?
9. Are qualified managers going to participate in the QFD process?
10. Do the potential participants possess formal QFD training?
11. Do potential participants have experience using QFD?

OVERVIEW

The most critical process element of a successful QFD implementation is the capture of the necessary information. This information comes from the **PEOPLE** involved in the planning, design, development and deployment of the product, process or service under the consideration. The QFD team will be an interdisciplinary group of experienced individuals representing each of the organizational functions associated with the targeted product, process or service. An additional prerequisite for team membership is an individual's enthusiasm and willingness to contribute.



- 1. R**esponsibilities of the project team.
- 2. E**xperience and skills of potential participants.
- 3. I**nterpersonal abilities of potential participants.
- 4. F**acilitator qualifications and selection.

{1. Responsibilities of the project team.}

IF CONSIDERED

BENEFITS TO BE ACHIEVED

- Definable and controllable process.
- Effective and efficient meetings with participants.
- Interest and enthusiasm of participants.
- Interest and support of management.

IMPLEMENTATION HINTS

- Define the problem precisely.
- Identify the goal, objectives, strategies and plan of action for QFD project.
- Prepare a project schedule.
- Organize an agenda for each working meeting.
- Distribute the results to participants in a timely fashion.
- Keep management informed on the progresses.
- Talk to the customer(s) in the context of the current QFD initiative.

IF NOT CONSIDERED

INDICATORS OF POOR PRACTICE

- Repetition of meetings for similar purposes.
- Capture of too much and/or unnecessary information.

BAD CONSEQUENCES

- Loss of management support.
- Loss of interest of participants.

{2. Experience and skills of potential participants. }

IF CONSIDERED

BENEFITS TO BE ACHIEVED

- Clear understanding of the product, process or service.
- Capture of required critical information.
- Understanding of the bottlenecks and problem areas.
- Understanding of responsibilities and concerns of each functional group, department or division.

IMPLEMENTATION HINTS

- Select participants from all disciplines, functional groups, departments and divisions involved in the product.
- Select individuals who are internally familiar with the product under consideration.
- Provide training in the use of QFD techniques.
- Select individuals familiar with the internal and external customers.
- Select individuals who demonstrate commitment to the project.

IF NOT CONSIDERED

INDICATORS OF POOR PRACTICE

- Time in working meetings spent in explaining QFD concepts.
- Time in working meetings spent discussing irrelevant organizational issues.
- Missing information.

BAD CONSEQUENCES

- Incorrect matrices leading to inappropriate solution.

{3. Interpersonal abilities of potential participants.}

IF CONSIDERED

BENEFITS TO BE ACHIEVED

- Less conflict between participants.
- Faster team building.
- More effective communication.
- Increased willingness to cooperate.
- Increased productivity of work group.

IMPLEMENTATION HINTS

- Choose team members with appropriate skills who work well together.
- Solicit help and input from other managers regarding unfamiliar potential members.
- Stress importance of interpersonal skills and teamwork (e.g. training).
- Appoint facilitator skilled in directing teams.

IF NOT CONSIDERED

INDICATORS OF POOR PRACTICE

- People reluctant to meet.
- Poor participation by members during sessions.
- Many sessions required to achieve the desired output.
- Animosity evident during working session.

BAD CONSEQUENCES

- Failure of QFD process to reach closure on issues.
- Reduced cooperation on other program and projects.

{4. Facilitator qualifications and selection.}***IF CONSIDERED*****BENEFITS TO BE ACHIEVED**

- Controllable meetings with participants.
- Unbiased discussions.
- Effective and efficient meetings.
- Appropriate use of required analysis tools.

IMPLEMENTATION HINTS

- Select facilitator having in-depth understanding of QFD and other continuous improvement tools.
- Select facilitator having good interpersonal relationship and communication skills.
- Facilitator should not be a mid-or upper-level manager.

IF NOT CONSIDERED**INDICATORS OF POOR PRACTICE**

- Dominance by individuals.
- Confusion in use of tools.

BAD CONSEQUENCES

- QFD project does not proceed on schedule.
- Decisions may not reflect the voice of the customer.

DISCUSSION AND SUMMARY

QFD techniques can be used at many levels of the organization, from high level strategic planning to component design. Once the decision has been made to apply QFD techniques, effectiveness of the QFD project team is dependent on the establishment and refinement of clearly defined objectives. Initially, the objectives will be strategic in nature, since the specific end user customer requirements will not yet have been identified. They may be in response to organizational desires for improvement of an existing product/process/service, or the initiation of a new product development. These strategic objectives become the areas of focus for new QFD projects. At a high level in the organization, objectives may be couched in terms of technical performance (e.g., "optimize hypersonic flight characteristics"), performance relative to funding constraints (e.g., "reduce cost of launch vehicle development"), or response to political pressures (e.g., "achieve U.S. market supremacy in mid-range passenger aircraft"). At lower levels in the organization, the initial objectives would be more specific (e.g., "optimize hypersonic fuel flow controls").

Once the QFD team has been formed, its first responsibility should be to set a goal and formulate a plan of action, a project schedule and rules of conduct for working group sessions. In most cases, the goal will be fairly well defined by the strategic objective which occasioned formulation of the team, but it must be formalized so that it functions as a project charter, from which events can be planned and progress measured. Planning, scheduling, budgeting and monitoring should be carried out in the same manner, and with the same tools, as employed on other projects in the organization. Publication of intermediate results and progress reporting to sponsors are additional team responsibilities which should not be overlooked.

The most important responsibility of the QFD team, however, is to be a team. Without the interdisciplinary exchange of information and cooperative decision making, the process breaks down. The participants' experience, skills, willingness, enthusiasm and interpersonal abilities are all required to create an environment conducive to effective teamwork. These attributes are of great importance when considering an individual for QFD team participation. In order for the working group sessions to proceed on schedule, each participant must be well versed in the use of QFD techniques. Section 5.3, which follows immediately, is dedicated to the design of a formal training program for QFD operatives.

QFD working group sessions proceed much more efficiently if conducted by a trained facilitator (Section 5.3 will discuss specialized training for facilitators). When an organization begins to use QFD as a continuous improvement tool, there is likely to be significant reliance on the facilitator to augment the process. As experience with the tool grows and spreads throughout the organization, the working groups will assume more responsibility for self-management, and the facilitator will become a resource for support and coordination.

DISCUSSION AND SUMMARY (Continued)

The facilitator, especially in the beginning, must have some special skills. A thorough working knowledge of QFD and other applicable continuous improvement tools is mandatory. He or she must have sufficient subject matter expertise to understand the content of the working group discussions, and also the analysis and communications skills to aid in the development and presentation of data and reports to team members and management. Motivation and conflict resolution skills are also valuable assets in the early stages. The facilitator must be able to maintain objectivity during the process, so that all views are equally represented. If possible, then, the first group of facilitators should be recruited from organizational areas which have no vested interest in the outcomes of the QFD projects, and facilitating should be their sole job function. As QFD expertise develops, members of the QFD teams, with some additional training, can (and should) serve as facilitators.

QUESTIONS TO BE ASKED

1. Have the goals, objectives, strategies, and plan of action for the QFD effort been defined?
2. Has the QFD project team prepared a schedule?
3. Have individual team member responsibilities been assigned?
4. Has the team established rules of conduct for meetings?
5. Have participants been selected from appropriate disciplines and functional groups?
6. As a group, does the QFD team possess the needed experience and skills?
7. Are team participants familiar with internal and external customers?
8. Has the right mix of participants been chosen to enhance teamwork and minimize interpersonal conflict?
9. Has a QFD qualified facilitator been appointed?
10. Is the facilitator adequately familiar with the problem subject and content?

OVERVIEW

It is critical for the participants in a QFD project to be familiar with the concepts. Some QFD success stories claim that internal training has contributed to the process in many ways. The training program should be designed for all potential users of the QFD tool, regardless of organizational functions. The QFD program must be customized for each application and organization due to differences in product, process and *CULTURE*.



- 1. D**efinition of program contents and requirements.
- 2. W**ho should conduct the meeting.
- 3. F**ramework and delivery of training.

{ 1. Definition of program contents and requirements. }

IF CONSIDERED

BENEFITS TO BE ACHIEVED

- Reduced doubt about capabilities of QFD.
- Increased receptiveness of QFD by managers.
- Dispel myths about using QFD as a tool.
- Effective training program.

IMPLEMENTATION HINTS

- Evaluate the organization's needs (technical, political, and cultural) prior to the training process to define the goal and objectives which are consistent with the organization.
- Provide an overview of prerequisites for QFD implementation.
- Provide a brief overview of QFD tools.
- Include well-defined organization guidelines for using QFD.
- Provide an overview of expected roadblocks during QFD process.
- Include organization related examples.
- Emphasis on analysis of outcome and deployment.

IF NOT CONSIDERED

INDICATORS OF POOR PRACTICE

- Poor participation in training program.
- Complaints from personnel regarding deficiencies in training program.

BAD CONSEQUENCES

- Reluctance by managers to use QFD.
- Unsuccessful attempts to use QFD.

{2. Who should conduct the training.}

IF CONSIDERED

BENEFITS TO BE ACHIEVED

- A program presented in a manner which best satisfies the organization needs.
- The right people to best deliver the program.

IMPLEMENTATION HINTS

- Select trainers who are well versed in QFD concepts and experienced in their application.
- Do not hesitate to employ professional trainers where in-house capability is not adequate.
- Have internal trainers participate with external trainers when used.

IF NOT CONSIDERED

INDICATORS OF POOR PRACTICE

- Dissatisfaction with program presentation.
- Frustration and lack of effectiveness by in-house trainers where they feel unqualified.

BAD CONSEQUENCES

- Time wasted participating in poorly presented training.
- Trainees develop dislike for QFD as a tool.
- Ineffective use of QFD.

{3. Framework and delivery of training.}

IF CONSIDERED

BENEFITS TO BE ACHIEVED

- Trainees are receptive to the training program.
- Training is applicable to needs of organization.

IMPLEMENTATION HINTS

- Make training augment the real environment.
- Design example(s) using data from organization related projects for hands-on practice.
- Reinforce the requirement for commitment of the project team members and management.
- Use training format tailored to trainee audience- facilitators, management and working group members.

IF NOT CONSIDERED

INDICATORS OF POOR PRACTICE

- People are reluctant to participate in training.
- All personnel classifications receive the same training.
- All training is rote learning of QFD procedures.

BAD CONSEQUENCES

- Training is inefficient
- Inability to carryout the QFD process.

DISCUSSION AND SUMMARY

Previous sections have indicated the need for participants in the QFD process to have a solid working knowledge of the tool and its applications. A formal training program is recommended to ensure adequate and consistent levels of expertise.

For the training program, the customers are the trainees and the organization in which QFD is to be employed. Their needs and desires must be identified and the program designed to satisfy them. Although there are many elements which comprise a formal training needs assessment, there are two essential things that the designers of the training program should do. First, they should consult with the organization's management to determine the technical, political and cultural climate in which QFD is to function. Then prospective trainees should be consulted to gain some insight regarding their organizational functions, levels of expertise and existing knowledge of QFD and other continuous improvement tools.

Instructors should be experienced in the development and implementation of similar training exercises and be well versed in QFD applications and techniques. Those who have implemented QFD in similar situations are best suited. If no one in the organization meets these criteria, external professionals should be contracted to develop and administer the program. In order to tailor the program to the unique requirements of the organization, in-house personnel should be assigned to work with the external trainers.

There are three distinct groups within the organization that should receive training: prospective working group members, prospective facilitators and managers. What each of these groups needs to know about the QFD process is unique. The programs designed for them, therefore, must also be unique. While the training requirements and content for working group members and facilitators should be evident, the requirements for non-participating managers may not be quite so clear. Managers must know the potential benefits and limitations of the process, in order to make enlightened decisions regarding where and when it should be applied, and also know what to expect from a successful implementation. The importance of complete management commitment to the QFD program should also be stressed during training.

The training program should be approached as any other in the organization, with formalized objectives, plans and schedules. Inasmuch as possible, training sessions should be scheduled so as to minimize impact on on-going operations, but should not be allowed to be continually put off in favor of "more important" activities. Training syllabi, instruction techniques and course materials should be derived from the master plans. In keeping with the requirement that the training be tailored to the organization and augment the work environment, it is recommended that illustrations/examples be drawn from real projects, either on-going or recently completed.

QUESTIONS TO BE ASKED

1. Have the organization's training needs been evaluated?
2. Have organization guidelines for QFD use been defined?
3. Does the training program satisfy organization's needs and guidelines?
4. Does the training plan address the mechanics of QFD use?
5. Does the training plan address the prerequisites for QFD implementation?
6. Does the training plan include emphasis on analysis of outcome?
7. Does the training plan include deployment of QFD outcomes?
8. Does the training plan include organization related examples?
9. Can the training be conducted by in-house personnel?
10. Is there adequate input by our organization into externally provided training?
11. Does the training program augment the actual task environment?
12. Does the training delivery format address the specific trainee audience?

OVERVIEW

The process of capturing the necessary information from the project teams involves conduct of a number of working group sessions. It is important to plan, organize and conduct *EFFECTIVE* and *EFFICIENT* sessions to best utilize the potential and knowledge of the team members.



- 1. S**ession format and agenda.
- 2. F**requency and duration of sessions.
- 3. R**ules of conduct and criterion definition.

{1. Session format and agenda.}

IF CONSIDERED

BENEFITS TO BE ACHIEVED

- Establishment of confidence by project team members.
- Continuous interest and enthusiasm of project team members in the project.
- Elimination of unnecessary information.
- Collection of accurate information in convenient format.

IMPLEMENTATION HINTS

- Establish well-defined goal(s) prior to each session.
- Prepare questions and questionnaires that stimulate the desired discussion and direct the process toward its goal.
- Designate an individual who is not a part of the project team for minute taking.
- Distribute minutes to project members before the next meeting.
- Publish analysis and intermediate results from the previous meeting.
- Inform the project members of project status/progress and plan of action for the next project milestone.

IF NOT CONSIDERED

INDICATORS OF POOR PRACTICE

- Decrease in attendance by project members.
- Longer sessions than planned.
- Repetition of sessions for similar goals.

BAD CONSEQUENCES

- Delay in the completion of the project.
- Discontinuance of QFD project.

{2. Frequency and duration of sessions.}

IF CONSIDERED

BENEFITS TO BE ACHIEVED

- Better attendance by participants.
- Continuity in the project.

IMPLEMENTATION HINTS

- Ensure meeting timing maintains continuity and momentum.
- Optimum length of 2 hours for each session.
- Assure timely *START* and *END* of meetings.

IF NOT CONSIDERED

INDICATORS OF POOR PRACTICE

- Complaints about session schedule.
- Decrease in attendance by participants.

BAD CONSEQUENCES

- Loss of confidence in the project by the participants.
- Frustrations by the participants.
- Loss of continuity.
- Stifling of creative thought.
- Decreased productivity in working group sessions.

{3. Rules of conduct and criterion definition.}

IF CONSIDERED

BENEFITS TO BE ACHIEVED

- Contribution by all participants.
- Inclusion of views of all functional groups, divisions and departments.

IMPLEMENTATION HINTS

- Prevent dominance by certain individuals.
- Prevent criticism of individuals responses.
- Develop method for conflict isolation.

IF NOT CONSIDERED

INDICATORS OF POOR PRACTICE

- Longer sessions than planned for.
- Debates between individuals.
- Lack of 100% participation.

BAD CONSEQUENCES

- Decrease in attendance by participants.
- Decrease in productivity of the sessions.
- Risk of missing important information.
- Poor performance in decision making.

DISCUSSION AND SUMMARY

It is obvious that representation by all involved functions at QFD sessions is critical for success. The way in which the sessions are planned and conducted, however, also has a significant bearing on the effectiveness of the process. Since a QFD session involves people responsible for critical functions in the organization, economical use of their time is an important consideration. The topic of a session should be well thought out, and each invitee should be notified well in advance in order to be prepared to participate. Data gathering sessions should be conducted by a non-participating facilitator/moderator and be supported by a recording secretary. The facilitator/moderator need not have a complete technical understanding of the session content (although he or she should be conversant in the terminology), but must ensure that the comments do not stray from the topic, that everyone has an equal opportunity to be heard, and that discussion/criticism of new ideas is minimized. Videotaping of sessions can be useful, but care must be taken that the device does not interfere with participants' willingness to voice all of their ideas. In sessions that are designed to reach a consensus or deliver a product, one participant should be designated to ensure that closure is reached.

The importance of feedback can not be overstated. It allows the team to maintain some coherence and momentum between sessions. Each participant should be provided information, on a timely basis, regarding pertinent data and outcomes of the sessions, and solicited for any additional inputs. Without this feedback, enthusiasm may wane and the quality of future sessions may suffer from lack of continuity. It is also advisable to keep participants informed regarding progress toward the stated objective(s) of the QFD process.

QUESTIONS TO BE ASKED

1. Has the purpose of the session been clearly defined?
2. Has an agenda been prepared for the session?
3. Have the questions to focus and stimulate process been prepared?
4. Have needed charts, graphs, and forms been prepared?
5. Have formal rules of conduct been addressed?
6. Are there dominant individuals?
7. Have the minutes and results of the previous session been distributed?
8. What is the desired outcome (or product) of the session?
9. Have goals and schedule for the next sessions been addressed as part of the current session?
10. What needs to be done as follow-up to the session?

OVERVIEW

The culture of an organization is an important determinant in its acceptance of QFD as meaningful continuous improvement tool. Organization here implies the formal structure or "wiring diagram", the formal and informal way of thinking about process, culture, the way things get done, the mores, communications, human resources, and physical resources.



- 1. I**mpact of organizational structure on personnel availability.
- 2. E**ffect of personnel empowerment on effective QFD use.
- 3. E**ffect of functional mapping on effective QFD use.

{ 1. Impact of organizational structure on personnel availability. }

IF CONSIDERED

BENEFITS TO BE ACHIEVED

- Managers and workers develop a common understanding of the roles and responsibilities of the QFD team members.
- QFD team outputs will better fulfill needs of others having program responsibilities.
- QFD acts as a bridge between functional areas within the organization.

IMPLEMENTATION HINTS

- Ensure potential QFD participants know program personnel and their responsibilities.
- Choose QFD participants across or within organizational boundaries that satisfy the functional needs of the program regardless of organizational affiliation.

IF NOT CONSIDERED

INDICATORS OF POOR PRACTICE

- Functional managers fail to assign the appropriate people to multidisciplinary QFD teams.
- Conflict develops during the QFD working meeting process. (due to lack of understanding of roles and responsibilities of team members)

BAD CONSEQUENCES

- Appropriate personnel will not be made available to the QFD teams.
- Benefits of QFD use will not be realized (due to communication stifling by organizational barriers).

{2. Effect of personnel empowerment on effective QFD use.}

IF CONSIDERED

BENEFITS TO BE ACHIEVED

- Decisions made within the QFD process carry the authority of the responsible organization functional area
- The time to reach meaningful decisions within the QFD process is reduced.
- QFD team members experience increased job satisfaction.

IMPLEMENTATION HINTS

- Ensure that decision making power resides within with the QFD team as a work group.
- Team members should possess representative decision making authority for their organization functional area.

IF NOT CONSIDERED

INDICATORS OF POOR PRACTICE

- Team members consulting frequently with managers outside the QFD team to obtain approval for decisions made in the QFD process.
- The time to reach acceptable decisions becomes lengthy.

BAD CONSEQUENCES

- Team members experience frustration with QFD process and become reluctant to participate.
- QFD process exceeds schedule requirements and increases project costs.
- The process degenerates to all discussion and no decisions.

{3. Effect of functional mapping on effective QFD use. }

IF CONSIDERED

BENEFITS TO BE ACHIEVED

- Organization realizes increased cross-functional cooperation and coordination.
- Productivity on project is enhanced by sharing of ideas in cross-functional teams.

IMPLEMENTATION HINTS

- Make the project functions the priority for assignment of personnel to the QFD team.
- Obtain commitment from functional managers for time and decision authority for QFD team members.
- Ensure representation by all organizational functions involved in the project.

IF NOT CONSIDERED

INDICATORS OF POOR PRACTICE

- QFD team lacks expertise in needed areas.
- Complaints of incomplete information and inexperience are prevalent during QFD process.

BAD CONSEQUENCES

- The right people are not assigned to the QFD team.
- Project performance suffers because of poor functional area support.

DISCUSSION AND SUMMARY

One of the most beneficial features of the QFD process is that it seeks to dispel the "business as usual" approach to planning and product/process design, and engender an philosophical approach that asks; "What outcome is desired (by the customer), and what is the most efficient and effective way to provide it?" In the public sector, organizations normally receive annual appropriations of funding to proceed on projects that have been authorized (based on policy decisions) by a sponsoring agency. Design decisions are often influenced by the extent to which the level of funding will allow modification/upgrade of existing products or services. That is what might be considered "business as usual." Application of QFD techniques would institute an approach to these decisions based on the most efficient and cost effective methods of satisfying the actual customer requirements, while treating the funding appropriations as constraints, rather than drivers, of the design.

While QFD can accomplish these kinds of objectives, it is an effective continuous improvement tool only if the structure and culture of the organization allows and encourages participation and commitment of individuals who have the technical expertise, organizational awareness and authority to make informed decisions and implement recommended actions. In many organizations, operational norms may need to be revised. Many mid-level managers will cease to be "directors" and find themselves as "team members." Functional managers will be required to "donate" the services of valued personnel to participate on QFD teams. Decision making authority will be removed from individuals and placed in the QFD teams. Direct horizontal lines of communication (between functions at the working level) will be established. To accomplish these changes requires a continuing commitment from upper management.

It is not suggested that QFD be used in every instance of organizational decision making. But as long as the organization supports the QFD process, it is possible for individual project or planning functions to be successfully conducted using QFD techniques.

QUESTIONS TO BE ASKED

1. Have program level responsibilities and personnel been defined for this QFD project?
2. Has the identity and responsibilities of the program personnel been passed to potential QFD participants?
3. Does the assignment of personnel to the QFD team meet the functional needs of the project?
4. Do organizational boundary issues remain that require resolution?
5. Has the QFD team been empowered to make product/process design decisions?
6. Do individual team members have decision making authority for their area of functional responsibility?

QFD IMPLEMENTATION PHASES

Quality Function Deployment (QFD) is a process for designing a product or service based on customer demands, by involving members of producer or supplier organization. It is sometimes referred as the most advanced form "Total Quality Control". In broader terms, QFD involves employees, and departments in improving or maintaining quality in order to give customers a product or service that is best qualified, most useful, and most economical. QFD is a concept that must be tailored for each organization and each application. However, four phases can be identified in applying QFD³:

- **Organization.** During this phase, the product or service to be improved, the appropriate multidisciplinary team and the focus of the QFD study are identified.
- **Description.** The project team defines the product or service based on customer demands, functions, parts, reliability and cost.
- **Breakthrough.** The project team identifies areas for improvement, finds methods to improve (through new technology and new concepts) and monitor the bottleneck in engineering process.
- **Implementation.** The project team defines the features of the new product, process or service, and how it should be will be developed.

There are a number of tools available to organize and analyze the information gathered during a QFD study, including the "Seven New Tools" (Affinity Diagram, Interrelationship Diagram, Tree Diagram, Matrix Diagram, Matrix Data Analysis, Process Decision Program and Arrow Diagram). In the following sections, Ckanek's et al. QFD project for the Space Transportation Main Engine (STME) is adopted for illustration.

³King, Bob, Better Designs In Half the Time, 1989.

ORGANIZING THE QFD PROJECT

- 1. Defining the Product/Process/Service.** The product, process or service under consideration needs to be defined. The project could be for existing products, processes or services as well as new product, process or service introductions.
- 2. Defining the Problem, Goal and Objectives.** The problem should be clearly defined including the customers of the product, "breakthroughs" required, focus area (if narrow or broad), and expectations. This definition must answer the question "*Why is the project being conducted?*".
- 3. Selection of a Team.** Following step 2, the functional groups, departments and divisions involved in the development of the product, process or service under consideration must be identified. The qualified individuals are selected to form a QFD project team.
- 4. Statement of Project.** Understanding the scope of the project, the amount of effort and information necessary to complete the task and expectations helps planning the QFD process. The start and end dates, level of organization involved, assignments of project team members, the QFD tools must be clearly defined.

DESCRIPTIVE PHASE

The working meetings (the heart of the QFD process) are designed and conducted to achieve the goal and objectives defined during the descriptive phase. Prior to these sessions, their format, duration, and time frame are established to achieve the objective of the meeting. The data obtained from the customers and working meetings is organized and analyzed using a tool. In this discussion, the Matrix Diagram of "Seven Tools" is adopted for illustrations which is usually referred as "HOUSE OF QUALITY" matrices in QFD terminology.

- 1. Customer Requirements (Whats).** Both internal and external customer requirements are captured during this stage. The quality factors are the customer demands and requirements. External customer's requirements are determined through surveys. However, the internal organizational requirements are identified during the working meetings. These requirements are then grouped and assigned to a heading which describes the information. These customer requirements are known as the "*WHATs*" or *quality factors/elements* in the House of Quality. The quality factors are assigned positions on the left side of the matrix (Exhibit 3).
- 2. Quality Characteristics (How's).** For each demanded quality factor, the effecting quality characteristics are defined during the working meetings. These are also grouped together into similar classes, and assigned positions across the top of the matrix (Exhibit 3).
- 3. Rate of Importance (ROI).** For each quality factor in the matrix, an importance rating is assigned. These ratings are (typically) determined by the participants in the working meetings. Each member assigns a rating based on their perceived importance of each particular quality factor, on a pre-established scale. The distributions of the ratings are discussed among the participants in order to come to a consensus (Exhibit 4).
- 4. Organization Now (O_n).** The organization's success in achieving that particular quality factor is determined through working meetings, using a rating scale similar to that used for ROI (Exhibit 4). This can be replaced with the current market status.
- 5. Organization Plan (O_p).** A rating is assigned through brainstorming sessions, on a scale similar to ROI and C_n , to indicate where the company wants to be positioned relative to the quality factor under consideration (Exhibit 4).

DESCRIPTIVE PHASE (Continued)

- 6. Rate of Improvement (IR).** For each quality factor, IR is calculated as follows (Exhibit 4):

$$IR = O_p / O_n$$

- 7. Absolute Weight (W_a).** For each quality factor, W_a is calculated as follows (Exhibit 4):

$$W_a = (IR) (ROI)(SP)$$

where SP = Sales Point which is assigned by the project team as a credit for the organization.

- 8. Demand Weight (W_d).** For each quality factor, W_d (%) is calculated as follows (Exhibit 4):

$$W_d = W_a / W_{a,j}$$

- 9. Correlation Weights (W_{co}).** The correlations between the quality factors and the quality characteristics are determined by assigning a weight. There are 9 correlation weights that can be used if applicable (Exhibit 5):

- "9" = strong (+) correlation
- "3" = moderate (+) correlation
- "1" = weak (+) correlation
- "-9" = strong (-) correlation
- "-3" = moderate (-) correlation
- "-1" = weak (-) correlation

- 10. Score.** For each correlation in the matrix, a score ($X_{i,j}$) is computed as follows:

$$X_{i,j} = (W_{d,j}) (W_{co,i,j})$$

- 11. Totals.** To complete the matrix, totals and percentages are computed and entered into the matrix for each quality factor and characteristic (Exhibit 6).

BREAKTHROUGH AND IMPLEMENTATION PHASES

The analysis of the matrix leads to understanding of the market, organization's position in the targeted market and the available product, process, or service opportunities. Most importantly, the matrix shows the "*critical areas and bottlenecks*" through ranking process for the product, process or service under study. These are considered the key potential areas for enhancements, improvements, control and monitor. During this phase, the project team identifies methods and techniques for improvements and prepares a plan of action for the implementation of these proposed methods. Regardless of new or existing product analysis, the following must be taken into consideration during this phase⁴:

- Product Planning
- Product Design
- Production
- Manufacturing
- Sales and Service
- Monitoring

⁴King, Bob, Better Designs In Half the Time, 1989.

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